APPENDIX F BASIC WELLHEAD PROTECTION AREA DELINEATION FOR THE STATE OF IDAHO

This appendix documents the three main components used for the derivation of the basic wellhead protection areas for the major aquifers in Idaho. These components are:

1. Data compilation
   a. The determination of transmissivity values from existing state wide pump test data.
   b. Compilation of hydrologic data values from literature search.
2. Hydrologic data value selection for the time of travel calculations.
3. The calculations of the time of travel boundaries for each hydrogeologic setting.

DATA COMPILATION

Hydrologic data for the major hydrogeologic settings in Idaho were compiled from two main sources:

- IDWR - Energy Division
- Literature search

Data from IDWR were used to derive transmissivities. The literature search compiled hydrologic information on transmissivities, aquifer thicknesses, hydraulic conductivity, gradient, and effective porosity.

IDWR - ENERGY DIVISION

Pump Test Data

The Energy Division of IDWR collected municipal well pump test data between 1987 and 1990. The purpose of the data was to determine the efficiency of municipal well pumps.

Of the 470 wells in the study, 131 had sufficient data (static water levels, pumping water levels and flow rates) to derive transmissivity values from the calculated specific capacity. The modified nonleaky artesian formula (Walton, 1962) was used to derive the transmissivity values. Pumping times of 45 minutes and a conservative storage coefficient of .0001 were used in the calculations for all wells except those determined to produce from the Rathdrum Prairie aquifer. The nominal radius of the well was estimated based on the flow rate of the well.

TABLE F-1: IDAHO DEPARTMENT OF WATER RESOURCES ENERGY DATA

Aquifer	City	Pumpid	Testdat	SWL	PWL	PWL-SWL	Flow	SC	Est R(')	Est R(")	T(art.)
Alluv	Challis	West Well #2	19880802	317.0	487.5	170.5	522	3.1	0.83	10	4690
Alluv	Rockland	25-hp Vertical Turbin	19890906	111.0	177.0	66.0	245	3.7	0.67	8	5970
Alluv	New Meadows	Submersible	19890901	19.0	78.0	59.0	253	4.3	0.67	8	6980
Alluv	Rockland	25-hp Submersible	19890906	111.0	177.0	66.0	322	4.9	0.67	8	8020
Alluv	Arimo	#1	19890717	30.0	56.0	26.0	346	13.3	0.67	8	23500
Alluv	Ketchum	Well #2	19880929	18.0	39.3	21.3	347	16.3	0.67	8	29100
Alluv	Bancroft	City Pump	19890719	95.0	104.0	9.0	188	20.9	0.67	8	38000
Alluv	Mackay	30-hp Submersible	19890913	11.0	27.0	16.0	420	26.2	0.83	10	47100
Alluv	Mackay	Well Pump #2	19910819	11.7	22.7	11.0	290	26.4	0.67	8	48700
Alluv	Tetonia	Park Well	19891107	101.0	110.0	9.0	395	43.9	0.83	10	81600
Alluv	Riggins	Well #2-new Pump	19900612	50.0	57.0	7.0	388	55.4	0.83	10	104000
Alluv	Grace	Well Pump	19890719	161.0	172.0	11.0	660	60.0	1.00	12	111000
Alluv	Bancroft	Railroad Pump	19890719	106.0	108.0	2.0	115	57.4	0.50	6	115000
Alluv	Ketchum	Well #1	19880929	59.3	75.6	16.3	1054	64.7	1.10	13.25	118000
Alluv	Malad	Five Points Well	19890718	78.0	82.0	4.0	263	65.7	0.67	8	129000
Alluv	Dayton	Park Well	19890718	52.0	56.0	4.0	333	83.3	0.83	10	161000
Alluv	Arco	Park Pump	19891016	125.0	135.0	10.0	906	90.6	0.00	12	172000
Alluv	Sun Valley	Pump #8	19880927	19.0	29.9	10.9	1139	104.5	1.10	13.25	198000
Alluv	Pocatello	Well #32	19880608	59.2	71.5	12.3	1604	130.4	1.10	13.25	251000
Alluv	Pocatello	Well #29	19880607	70.8	87.9	17.1	2493	145.8	1.27	15.25	277000
Alluv	Pocatello	Well #2	19880607	34.9	43.5	8.6	1265	147.0	1.10	13.25	285000
Alluv	Sun Valley	Pump #5	19880927	12.5	16.0	3.5	787	224.9	1.00	12	452000
Alluv	Pocatello	Well #27	19880607	63.3	69.2	5.9	1623	275.2	1.10	13.25	554000
Alluv	Sun Valley	Pump #7	19880927	20.0	23.5	3.5	1039	296.9	1.10	13.25	601000
Alluv	Pocatello	Well #18	19880608	66.2	72.6	6.4	2020	315.5	1.27	15.25	630000
Alluv	Pocatello	Pip Well	19880608	69.6	72.6	3.0	1188	395.8	1.10	13.25	815000
Alluv	Malad	Spring Creek Well/5	19890718	84.0	85.0	1.0	413	413.2	0.83	10	881000
Alluv	Pocatello	Well #16	19880607	46.7	49.5	2.8	2267	809.8	1.27	15.25	1710000
Alluv	Pocatello	Well #28	19880607	34.6	35.9	1.3	1755	1349.8	1.27	15.25	2930000
Alluv	Pocatello	Well #31	19880608	62.2	64.1	1.9	2937	1546.0	1.27	15.25	3380000
Alluv	Pocatello	Well #12	19880607	43.3	44.7	1.4	2812	2008.2	1.27	15.25	4460000
Alluv	Pocatello	Well #10	19880607	52.4	53.9	1.5	3419	2279.5	1.60	19.25	4970000
Alluv	Pocatello	Well #21	19880607	79.6	80.1	0.5	1581	3161.8	1.10	13.25	7300000
Alluv	Pocatello	Cree Well	19880606	35.4	35.5	0.1	388	3877.0	0.83	10	9320000
Alluv	Pocatello	Well #22	19880607	87.5	87.6	0.1	871	8714.0	1.10	13.25	2E+07
CR Basalt	Kooskia	Well #3	19881004	101.0	350.0	249.0	246	1.0	0.67	8	1420
CR Basalt	Council	Pump #1	19870619	277.2	374.2	97.0	337	3.5	0.83	10	5380
CR Basalt	Moscow	Cemetary Well	19880822	170.4	228.2	57.8	467	8.1	0.83	10	13300
CR Basalt	Moscow	Cemetary Well	19880822	170.4	228.2	57.8	708	12.3	1.00	12	20300
CR Basalt	Council	Pump #2	19870619	50.0	79.2	29.2	356	12.2	0.83	10	20700
CR Basalt	Kooskia	Well #1	19881004	43.5	64.0	20.5	248	12.1	0.67	8	21200
CR Basalt	Kooskia	Well #2	19881004	45.5	66.0	20.5	255	12.4	0.67	8	21800
CR Basalt	Univ of Idaho	Well #4	19880824	195.0	295.4	100.4	1901	18.9	1.27	15.25	31300
CR Basalt	Moscow	Well #8	19880822	370.2	404.9	34.7	980	28.2	1.10	13.25	49000
CR Basalt	Moscow	Well #6	19880823	344.9	376.1	31.2	1339	42.9	1.10	13.25	76700
CR Basalt	Moscow	Well #2	19880822	138.7	153.8	15.1	864	57.2	1.10	13.25	104000
CR Basalt	Univ of Idaho	Well #3	19880824	297.0	301.0	4.0	1812	453.1	1.27	15.25	924000
CR Basalt	Lewiston	Well #5	19880713	150.6	152.0	1.4	1180	842.6	1.10	13.25	1810000
E. Snake	Hollister	Well Pump	19890816	158.0	189.0	31.0	197	6.4	0.50	6	11100
E. Snake	Roberts	Well #2	19880626	23.9	47.1	23.2	407	17.6	0.83	10	30600
E. Snake	Filer	Pump #5	19870603	42.4	60.4	18.0	345	19.2	0.83	10	33700
E. Snake	Teton	Well #2	19891019	91.5	100.0	8.5	252	29.6	0.67	8	55300

Header Explanation for Table F- 1

Aquifer = Aquifer Name
- Alluv = Unconsolidated Alluvium
- CR Basalt = Columbia River Basalts
- E. Snake = Eastern Snake River Plain Basalts
- MVS-VS = Mixed Volcanic and Sedimentary Rocks, Primarily Volcanic Rocks
- MVS-Sed = Mixed Volcanic and Sedimentary Rocks, Primarily Sedimentary Rocks
- Rathdrum = Rathdrum Prairie Aquifer

City = City location of the well
Pumpid = Well identification
SWL = Static water level, in feet
PWL = Pumping water level, in feet
PWL-SWL = Difference between PWL and SWL, in feet
Flow = Calculated flow rate, in gallons per minute (gpm)
SC = Specific capacity, in gallons per minute per foot of drawdown
Est R('); Est R(") = Estimated radius of the well in feet; inches
T(art.) = Transmissivity, in gallons per day per foot (gpd/ft) (Uses confined aquifer storage coefficient)

TABLE F-1 Continued

Aquifer	City	Pumpid	Testdat	SWL	PWL	PWL-SWL	Flow	SC	Est R(')	Est R(")	T(art.)
E. Snake	Roberts	Well #3	19880626	64.4	87.6	23.2	727	31.3	1.00	12	55500
E. Snake	Shelley	Pump #4	19880525	103.0	144.6	41.6	1422	34.2	1.10	13.25	60200
E. Snake	Shelley	Pump #1	19880525	107.7	125.0	17.3	576	33.3	0.83	10	60800
E. Snake	Burley	#1	19890804	205.0	228.0	23.0	821	35.7	1.00	12	63800
E. Snake	Ashton	#1	19890912	28.0	44.0	16.0	900	56.3	1.00	12	103000
E. Snake	Aberdeen	Well #2	19870604	25.0	33.0	8.0	634	79.2	0.83	10	153000
E. Snake	Ammon	Well #6	19880524	86.0	102.2	16.2	1340	82.7	1.10	13.25	154000
E. Snake	Idaho Falls	Well #15 Main	19870626	106.0	124.0	18.0	2093	116.3	1.27	15.25	218000
E. Snake	Ririe	Pump #2	19871029	34.0	35.0	1.0	106	106.3	0.50	6	221000
E. Snake	Iona	Tank Pump	19870625	207.0	216.5	9.5	1312	138.1	1.27	15.25	261000
E. Snake	Rigby	Shop Well	19891018	15.0	22.0	7.0	1047	149.5	1.10	13.25	290000
E. Snake	Ammon	Well #7	19880524	65.0	74.4	9.4	1410	150.0	1.10	13.25	291000
E. Snake	Burley	#4	19890804	222.0	230.0	8.0	1227	153.3	1.17	14	295000
E. Snake	Rupert	Well #1	19890801	185.0	190.0	5.0	833	166.7	1.10	13.25	325000
E. Snake	Idaho Falls	Well #11 1435 RPM	19870624	195.0	208.0	13.0	3587	276.0	1.94	23.25	518000
E. Snake	Ririe	Pump #3	19871029	40.0	41.0	1.0	251	251.0	0.67	8	533000
E. Snake	Idaho Falls	Well #4 Main	19870623	155.0	172.0	17.0	4942	290.7	1.94	23.25	547000
E. Snake	Rigby	Well Pump #2	19891018	15.0	22.0	7.0	2441	348.8	1.27	15.25	700000
E. Snake	Idaho Falls	Well #11 1610 RPM	19870624	195.0	208.0	13.0	4861	373.9	1.10	13.25	767000
E. Snake	Dubois	Well #1	19891020	355.0	356.0	1.0	404	403.6	0.83	10	860000
E. Snake	Rigby	Harwood #3	19891018	15.0	16.0	1.0	420	419.9	0.83	10	896000
E. Snake	Dubois	Well #3	19891020	355.0	356.0	1.0	613	613.1	0.83	10	1330000
E. Snake	Shelley	Pump #3	19880525	92.6	95.7	3.1	1995	643.4	1.27	15.25	1340000
E. Snake	Shoshone	Pump #3	19871029	210.8	212.1	1.3	824	633.9	1.00	12	1350000
E. Snake	Rexburg	Well #5	19891017	324.0	327.0	3.0	2060	686.7	1.27	15.25	1430000
E. Snake	Rupert	Well #2`	19890801	185.0	187.0	2.0	1681	840.3	1.10	13.25	1800000
E. Snake	Rexburg	Well #1	19891017	208.0	210.0	2.0	2188	1093.8	1.27	15.25	2350000
E. Snake	Rexburg	Well #6	19891017	208.0	210.0	2.0	2246	1122.8	1.27	15.25	2410000
E. Snake	Jerome	Well Pump #2	19890816	284.8	285.8	1.0	1396	1396.4	1.27	15.25	3040000
E. Snake	Idaho Falls	Well #2 Main	19870622	167.0	169.0	2.0	2803	1401.3	1.27	15.25	3050000
E. Snake	Jerome	Well Pump #1	19890816	284.8	285.8	1.0	1493	1492.9	1.10	13.25	3310000
E. Snake	Idaho Falls	Well #3	19870626	165.0	166.0	1.0	4719	4718.6	1.94	23.25	1E+07
MVS-VS	Kuna	Process Pump	19880815	240.0	310.5	70.5	223	3.2	0.67	8	5030
MVS-VS	Kuna	Well #2	19880815	93.7	112.3	18.6	580	31.2	1.00	12	55300
MVS-VS	Kuna	Well #3	19880815	84.6	115.9	31.3	1801	57.5	1.27	15.25	102000
MVS-VS	Grandview	Pump #2	19880830	82.7	85.4	2.7	226	83.5	0.67	8	166000
MVS-VS	Grandview	Pump #1	19880830	79.7	82.1	2.4	246	102.5	0.67	8	206000
MVS-SED	Homedale	Well #2	19880602	44.2	222	178.1	198	1.1	0.5	6	1700
MVS-SED	Homedale	Old City Hall Well	19880602	41.8	216.0	174.2	206	1.2	0.67	8	1730
MVS-SED	Eagle	#2 Submersible	19910520	50.9	133.8	82.9	266	3.2	0.67	8	5100
MVS-SED	Nampa	Well #10	19880518	17.0	191.0	174.0	605	3.5	0.83	10	5380
MVS-SED	Caldwell	Well #9 1670 RPM	19880816	50.5	233.2	182.7	779	4.3	1.00	12	6510
MVS-SED	Caldwell	Well #13	19880816	10.7	149.5	138.8	772	5.6	1.00	12	8680
MVS-SED	Caldwell	Well #10	19880816	11.6	145.0	133.4	751	5.6	1.00	12	8790
MVS-SED	Homedale	Park Well	19880602	4.6	42.5	37.9	207	5.5	0.67	8	9050
MVS-SED	Nampa	Well #8	19880517	56.1	171.2	115.1	862	7.5	1.10	13.25	11700
MVS-SED	Caldwell	Well #7 1870 RPM	19880816	6.0	110.0	104.0	889	8.5	1.00	12	13700
MVS-SED	Parma	Well #7	19880826	24.5	138.4	113.9	1033	9.1	1.10	13.25	14400
MVS-SED	Caldwell	Well #11	19880816	10.6	112.2	101.6	986	9.7	1.00	12	15800
MVS-SED	Wilder	Pump #2	19880823	98.0	132.0	34.0	337	9.9	0.83	10	16600
MVS-SED	Caldwell	Well #6	19880816	9.5	90.0	80.5	864	10.7	1.00	12	17600

Header Explanation for Table F- 1

Aquifer = Aquifer Name
- Alluv = Unconsolidated Alluvium
- CR Basalt = Columbia River Basalts
- E. Snake = Eastern Snake River Plain Basalts
- MVS-VS = Mixed Volcanic and Sedimentary Rocks, Primarily Volcanic Rocks
- MVS-Sed = Mixed Volcanic and Sedimentary Rocks, Primarily Sedimentary Rocks
- Rathdrum = Rathdrum Prairie Aquifer

City = City location of the well
Pumpid = Well identification
SWL = Static water level, in feet
PWL = Pumping water level, in feet
PWL-SWL = Difference between PWL and SWL, in feet
Flow = Calculated flow rate, in gallons per minute (gpm)
SC = Specific capacity, in gallons per minute per foot of drawdown
Est R('); Est R(") = Estimated radius of the well in feet; inches
T(art.) = Transmissivity, in gallons per day per foot (gpd/ft) (Uses confined aquifer storage coefficient)

TABLE F-1 Continued

Aquifer	City	Pumpid	Testdat	SWL	PWL	PWL-SWL	Flow	SC	Est R(')	Est R(")	T(art.)
MVS-SED	Caldwell	Well #14	19880817	34.9	85.8	50.9	679	13.3	0.83	10	22800
MVS-SED	Garden City	#1	19890726	132.5	160.0	27.5	368	13.4	0.83	10	22900
MVS-SED	Caldwell	Well #8 1200 RPM	19880817	9.4	39.4	30.0	566	18.9	1.00	12	32200
MVS-SED	Notus	#2	19890524	30.0	55.0	25.0	490	19.6	0.83	10	34500
MVS-SED	Nampa	Colorado	19880619	9.5	45.0	35.5	774	21.8	1.00	12	37700
MVS-SED	Nampa	Well #7	19880518	11.3	41.8	30.5	823	27.0	1.10	13.25	467o0
MVS-SED	Nampa	Well #9 1280 RPM	19880518	1.0	18.5	17.5	458	26.2	0.83	10	47000
MVS-SED	Eagle	#1 Submersible	19910520	40.0	59.0	19.0	539	28.4	0.83	10	51200
MVS-SED	Garden City	#5 (Variable Speed)	19890726	22.0	36.0	14.0	490	35.0	0.83	10	64100
MVS-SED	Middleton	Pump #4	19890808	86.0	135.0	49.0	1903	38.8	1.27	15.25	87600
MVS-SED	Nampa	Well #6	19880517	32.0	49.0	17.0	830	48.8	1.10	13.25	88100
MVS-SED	Caldwell	Well #4	19880817	74.0	80.3	6.3	295	46.9	0.67	8	89900
MVS-SED	Garden City	#43	19890727	15.0	35.0	20.0	1219	60.9	1.10	13.25	111000
MVS-SED	Nampa	Holly	19880619	17.3	27.5	10.2	695	68.1	1.00	12	127000
MVS-SED	Eagle	#3 Submersible	19910520	65.5	69.2	3.7	259	69.9	0.67	8	137000
MVS-SED	Nampa	19th Ave. N.	19880619	3.1	10.0	6.9	591	85.6	1.00	12	162000
MVS-SED	Nampa	Venice	19880519	16.8	22.0	5.2	462	88.8	0.83	10	172000
MVS-SED	Nampa	Juniper Square	19880619	23.0	24.0	1.0	137	137.1	0.50	6	290000
Rathdrum	Coeur d'Alene	Atlas Road Well	19870804	241.0	245.0	4.0	1155	288.7	1.10	13.25	58300
Rathdrum	Coeur d'Alene	Fourth St. Well	19870804	194.5	212.0	17.5	3238	185.0	1.60	19.25	347000
Rathdrum	Coeur d'Alene	Linden St. Well	19870804	169.0	178.0	9.0	2604	289.3	1.27	15.25	574000
Rathdrum	Coeur d'Alene	Atlas Road Well		241.0	245.0	4.0	1155	288.8	1.10	13.25	583000
Rathdrum	Coeur d'Alene	Locust St. Well	19870804	174.0	175.8	1.8	1655	919.7	1.10	13.25	1980000

Header Explanation for Table F- 1

Aquifer = Aquifer Name
- Alluv = Unconsolidated Alluvium
- CR Basalt = Columbia River Basalts
- E. Snake = Eastern Snake River Plain Basalts
- MVS-VS = Mixed Volcanic and Sedimentary Rocks, Primarily Volcanic Rocks
- MVS-Sed = Mixed Volcanic and Sedimentary Rocks, Primarily Sedimentary Rocks
- Rathdrum = Rathdrum Prairie Aquifer

City = City location of the well
Pumpid = Well identification
SWL = Static water level, in feet
PWL = Pumping water level, in feet
PWL-SWL = Difference between PWL and SWL, in feet
Flow = Calculated flow rate, in gallons per minute (gpm)
SC = Specific capacity, in gallons per minute per foot of drawdown
Est R('); Est R(") = Estimated radius of the well in feet; inches
T(art.) = Transmissivity, in gallons per day per foot (gpd/ft) (Uses confined aquifer storage coefficient)

Of the 131 wells, 36 wells were determined to be producing from the Eastern Snake River Plain Basalts, 13 from the Columbia River Basalts, 35 from unconsolidated alluvium, 32 from mixed volcanics and sedimentary rocks (primarily sedimentary), 5 from the Rathdrum Prairie, and 5 from mixed volcanics and sedimentary rocks (primarily volcanic rocks). The derived transmissivity values for the Rathdrum Prairie Aquifer and mixed volcanics and sedimentary rocks (primarily volcanic rocks) were not used because there were not enough data points.

Individual well data and the derived transmissivity values are tabulated by hydrogeologic setting in Table F-1. Average (log mean) transmissivity values are listed in Table F-2.

Table F-2 Average Transmissivity Values IDWR Energy Pump Test Data

Hydrogeologic Setting	#Data Points	Type of Distribution	Average Value (GPD/FT)
East Snake River Plain Basalts	36	Log	352,091
Columbia River Basalts	13	Log	38,435
Alluvium	35	Log	247,711
Mixed Volcanic and Sedimentary Rocks (Primarily sedimentary rocks)	32	Log	26,812

Note: Data for the following aquifers were not used because there were insufficient data points: Mixed Volcanic and Sedimentary (primarily volcanic rocks), Rathdrum Prairie

Literature Search Data

Hydrologic data for transmissivity, aquifer thickness, hydraulic conductivity, gradient, and effective porosity were obtained from literature search and are compiled in Table F-3. The reference numbers on the table correspond to the list of references for this appendix.

Transmissivity (T)

Transmissivity is the rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media (Fetter, 1988).

To allow ready comparison, all transmissivity data have been converted to gpd/ft if the literature gave the value in units of ft^2/day. The converted values were not rounded.

Table F-3: Hydrologic Data and References for the Basic I Calculations, Idaho Wellhead Protection Program

Hydrogeologic Setting	Transmissivity (T)	Aquifer Thickness (b)	Hydraulic Conductivity (K)	Hydraulic Gradient (I)	Effective Porosity (Ne)	Values Used for Basic I Calculations
East Snake River Plain Basalts	650,000 - 67,240,000 gpd/ft Ref: (12,21,25, 26) 400,000 gpd/ft (Avg) Ref: (18)	Several 100 to 1,000 ft. Ref: (21) 500 - 4,000 ft. Ref: (20)	3,740 - 37,400 gpd/ft^2 Min = 74.8 gpd/ft^2 Max = 74,800 gpd/ft^2 Ref: (2, 23)	.001 - .006 Ref: (23) Gradient as low as .0003 exist. Ref: (26)	.11 - .19 Ref: (3, 17)	T = 400,000 gpd/ft b = 600 ft. I = 0.004 Ne = 0.15
Columbia River Basalts	20,196 - 2,019,600 gpd/ft Ref: (1) 40,000 gpd/ft (Avg) Ref: (18)	20 - 800 ft. Ref: (1, 8)		.0002 Ref: (24)	.004 - .19 Ref: (4) 0.0002 Ref: (13)	T = 40,000 gpd/ft b = 400 ft. I = 0.0002 Ne = 0.1
Rathdrum Prairie	2,019,600 - 97,240,000 gpd/ft Ref: (10,16)	500 - 1,000 ft. Ref: (10, 6) 250 - 400 ft. Ref: (27)	3,740 - 164,560 gpd/ft^2 Ref: (10, 16)	.0004 - .005 Ref: (10, 16) .0005 - .009 Ref: (27)	.25 - .30 Ref: (10)	See Rethdrum Prairies Aquifer delineation in Chapter 3.
Unconsolidated Alluvium	200,000 gpd/ft. (Avg) Ref: (18)	100 ft. estimated	74.8 - 2,992 gpd/ft^2 Ref: (10, 16)	.003 - .02 Ref: (5, 6, 7)	.20 - .35 Ref: (11)	T = 200,000 gpd/ft b = 100 ft. I = 0.01 Ne = 0.3
Mixed Volcanic and Sedimentary Rocks - Primarily Sedimentary Rocks (Example: Boise/ Nampa area)	6,732 - 160,820 gpd/ft Ref: (29) 30,000 gpd/ft (Avg) Ref: (18)	500 - 4,000 ft. Ref: (29) 500 - 1,000 ft. Ref: (33)	74.8 - 748 gpd/ft^2 upper 500 ft. Ref: (29)	.002 - .004 Ref:(22)	.10 - .30 Ref: (11)	T = 30,000 gpd/ft b = 800 ft. I = 0.003 Ne = 0.2
Mixed Volcanic and Sedimentary Rocks - Primarily Volcanic Rocks (Example: Mtn Home)	374,000 gpd/ft Ref: (35)	500 - 600 ft. Ref: (30)		.012 - .015 Ref: (22)	.11 - .19 Ref: (11)	T = 400,000 gpd/ft b = 600 ft. I = 0.01 Ne = 0.2

Aquifer Thickness (b)

The pertinent aquifer thickness is the saturated thickness of the aquifer. These values are expressed in units of feet.

Hydraulic Conductivity (K)

The hydraulic conductivity of an aquifer is the coefficient of proportionality describing the rate at which water can move through a permeable medium. (Fetter, 1988).

To allow ready comparison, all hydraulic conductivity data have been converted to gpd/ft^2 if the literature gave the value in units of ft/day. The converted values were not rounded.

Hydraulic Gradient (I)

In general terms, hydraulic gradient is a measure of the change of total head in any given direction (Fetter, 1988). The hydraulic gradient in the table is the change in total head in a horizontal distance. It is a dimensionless value because the units are length/length.

Effective Porosity (n_e)

Effective porosity is the volume of the void spaces through which water or other fluids can travel in a rock or sediment divided by the total volume of the porous medium.

DATA VALUE SELECTION

From the compilation of information, values for transmissivity, aquifer thickness, hydraulic conductivity, gradient, and effective porosity for each of the hydrogeologic settings were selected to calculate the basic wellhead protection areas.

The rationale for the selection of each of the values for five of the hydrogeologic settings are discussed in this section.

EASTERN SNAKE RIVER PLAIN BASALTS

Transmissivity:

The transmissivity value from IDWR - Energy Division data was selected for the following reasons:

1. There were sufficient data points located in the Eastern Snake River Plain Basalts from this study.

2. Data from a consistent source, if possible, were desirable for the calculations of the basic delineation for all the hydrogeologic settings. The Technical Task Force agreed that IDWR - Energy Division data would be the most consistent source of transmissivity data.

   The log mean transmissivity value calculated from IDWR - Energy Division data for the Eastern Snake River Plain Basalts was 352,091 gpd/ft, which was rounded to one significant figure, 400,000 gpd/ft. The Technical Task Force recognized that IDWR - Energy Division value did not fall within the transmissivity range compiled from the literature search. However, the decision was made to maintain the concept of using a consistent source of information. The Technical Task Force came to this conclusion after much debate and with the realization that the selection of any one value in an aquifer, such as the Eastern Snake River Plain Aquifer, with large magnitudes of variation in transmissivity will not ever be entirely representative of any given specific area. The overriding concept that led to the final decision was that the intent of the basic delineation approach is not to define specific wellhead protection areas, but rather is to develop guidelines for that aquifer.

Aquifer Thickness:

The value for aquifer thickness was derived by averaging the thickness range of 100 - 1000 feet and by rounding to one significant figure. The value of 4,000 feet was not believed to be a thickness relevant to the depth of drinking water supplies in this aquifer.

Hydraulic Conductivity:

The hydraulic conductivity value was calculated from the selected transmissivity and selected aquifer thickness value. Hydraulic conductivity would equal transmissivity divided by aquifer thickness.

Hydraulic Gradient:

The value for the hydraulic gradient was derived by averaging the range of .001 - .006 and by rounding to one significant figure.

Effective Porosity:

The value for the effective porosity was derived by averaging the range of .11 - .19.

COLUMBIA RIVER BASALTS

Transmissivity:

The transmissivity value from IDWR - Energy Division data was selected for the following reasons:

1. There were sufficient data points located in the Columbia River Basalts from this study.
2. Data from a consistent source, if possible, were desirable for the calculations of the basic delineation for all the hydrogeologic settings. The Technical Task Force agreed that IDWR - Energy Division data would be the most consistent source of transmissivity data.

The log mean transmissivity value calculated from IDWR - Energy Division data was 38,436 gpd/ft, which was rounded to 40,000 gpd/ft.

Aquifer Thickness:

The value for aquifer thickness was derived by averaging the range of 20 - 800 feet and by rounding to one significant figure.

Hydraulic Conductivity:

The hydraulic conductivity value was calculated from the selected transmissivity and selected aquifer thickness value. Hydraulic conductivity would equal the transmissivity divided by the aquifer thickness.

Hydraulic Gradient:

One reference for this value was found therefore this value, .0002, was selected.

Effective Porosity:

The value for effective porosity was derived by averaging the range of .004 - .19 and by rounding to one significant figure.

UNCONSOLIDATED ALLUVIUM

Transmissivity:

The transmissivity value from IDWR - Energy Division data was selected for these reasons:

1. There were sufficient data points for the unconsolidated alluvium aquifer type from this study.

2. Data from a consistent source, if possible, were desirable for the calculations of the basic delineation for all the hydrogeologic settings. The Technical Task Force agreed that IDWR - Energy Division data would be the most consistent source of transmissivity data.

The log mean transmissivity value calculated from IDWR - Energy Division data was 247,711 gpd/ft, which was rounded to 200,000 gpd/ft.

Aquifer Thickness:

The value of 100 feet was an estimation based on the typical depth of wells in this aquifer type.

Hydraulic Conductivity:

The hydraulic conductivity value was calculated from the selected transmissivity and selected aquifer thickness value. Hydraulic conductivity would equal the transmissivity divided by the aquifer thickness.

Hydraulic Gradient:

The value for the hydraulic gradient was derived by averaging the range of .003 - .02 and by rounding to one significant figure.

Effective Porosity:

The value for effective porosity was derived by averaging the range of .20 - .35 and by rounding to one significant figure.

MIXED VOLCANIC AND SEDIMENTARY ROCKS - PRIMARILY SEDIMENTARY ROCKS

Transmissivity

The transmissivity value from IDWR - Energy Division data was selected for these reasons:

1. There were sufficient data points for the unconsolidated alluvium aquifer type from this study.

2. Data from a consistent source, if possible, were desirable for the calculations of the basic elineation for all the hydrogeologic settings. The Technical Task Force agreed that IDWR - Energy Division data would be the most consistent source of transmissivity data.

The log mean transmissivity value calculated from IDWR - Energy Division data was 26,812 gpd/ft, which was rounded to 30,000 gpd/ft.

Aquifer Thickness:

The value for aquifer thickness was derived by averaging the thickness range of 500 - 1000 feet. At depths greater than 1000 feet it is very likely that the ground water encountered is geothermal and therefore, would not be used for drinking water purposes.

Hydraulic Conductivity:

The hydraulic conductivity value was calculated from the selected transmissivity and selected aquifer thickness value. Hydraulic conductivity would equal the transmissivity divided by the aquifer thickness.

Hydraulic Gradient:

The value for hydraulic gradient was derived by averaging the range of .002 - .004.

Effective Porosity:

The value for effective porosity was derived by averaging the range of .10 - .30.

MIXED VOLCANICS AND SEDIMENTARY ROCKS - PRIMARILY VOLCANIC ROCKS

Transmissivity:

The transmissivity value from the literature search was selected because there were not enough data points for this aquifer type from IDWR - Energy Division study.

The literature value of 374,000 gpd/ft was rounded to 400,000 gpd/ft.

Aquifer Thickness:

The value for aquifer thickness was derived by averaging the range of 500 - 600 feet and by rounding to one significant figure.

Hydraulic Conductivity:

The hydraulic conductivity value was calculated from the selected transmissivity and selected aquifer thickness value. Hydraulic conductivity would equal the transmissivity divided by the aquifer thickness.

Hydraulic Gradient:

The value for hydraulic gradient was derived by averaging the range of .012 - .015 and by rounding to one significant figure.

Effective Porosity:

The value for effective porosity was derived by averaging the range of .11 - .19 and by rounding to one significant figure.

DETERMINATION OF BASIC I TIME OF TRAVEL BOUNDARIES

Background

The radii calculations are based on advective transport and have taken into consideration the velocity of ground water around pumping wells and the velocity of the natural regional ground water flow. The calculated distance is in an upgradient direction from the well.

The derivation of the velocity of ground water flow around pumping wells is an additive process of the average linear velocity equation and the Theis equation. The average linear velocity is a velocity representing the rate at which water moves through the pore spaces. The Theis equation predicts the drawdown in hydraulic head in a confined aquifer at any distance "r" from a well at any time "t" after the start of pumping if the aquifer properties of transmissivity (T), storativity (S), and pumping rate (Q) are known.

Average linear velocity equation:

$$v = (K/n_e)(ds/dr)$$

where,

K = hydraulic conductivity, in gallons per day per ft^2 (gpd/ft^2)

n_e = effective porosity

(ds/dr)= hydraulic gradient around the well

Theis equation:

$$s = (Q/4\pi T) \int e^{-u}/u)du, \text{ where } u = (r^2S/4Tt) \text{ and } (du/dr) = (2rS/4Tt)$$

If the This equation is expanded and differentiated with respect to "r" , the factor, (ds/dr), can be substituted into the linear velocity equation to simplify the equation to:

$$v = (K/n_e)(Q/2\pi Tr)\, e^{(-r2S/4Tt)}$$

where,

Q = flow rate in gallons per day (gpd)

T = transmissivity in gallons per day per ft (gpd/ft)

r = distance between observation point and well in feet

S = storativity

s = drawdown in feet

t = time in days

At equilibrium, i.e. when "t" is very large, $e^{(-r2S/4Tt)}$ will approximate 1, so the velocity equation can be simplified to:

$$v = (K/n_e)(Q/2\pi Tr)$$

The velocity equation used to calculate the radius (including the conversion factor of 1 ft^3/day = 7.48 gal/day) is:

$$(K/7.48 \times n_e)(ds/dr) + (K/7.48 \times n_e)(Q/2\pi Tr)$$

A program has been developed to compute the distance from a wellhead that a particle would need to be in order to arrive at the wellhead in up to ten (10) years. The calculation assumes:

- That the well has been pumping at the specified flow rate for a very long tme such that an equilibrium velocity is established;
- a straight line from the point of origin of the parcel and the well; and
- that the regional groundwater flow is in the direction of the parcel flow.

Calculated radii for the various hydrogeologic settings and different pumping rates are given in Tables 4.8a - e in "Wellhead Protection Area Delineation," page 4-19 to 4-21.

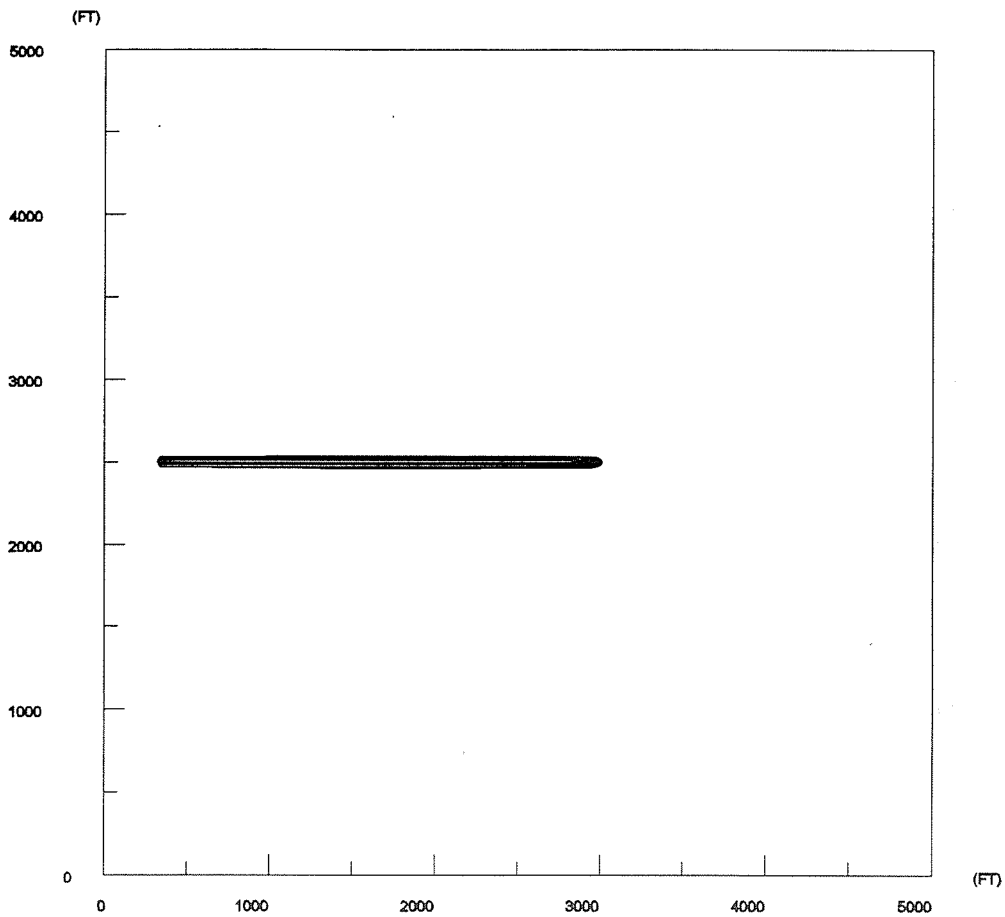
CODE VERIFICATION

The results of the calculations for the 3 year and the 6 year time of travel wellhead protection areas were spot checked with results calculated from the WHPA Code 2.0, which is a modular semi-analytical model developed by EPA.

The calculations for the 3 year and the 6 year wellhead protection areas are comparable

(See Figures F-1 through F-4).

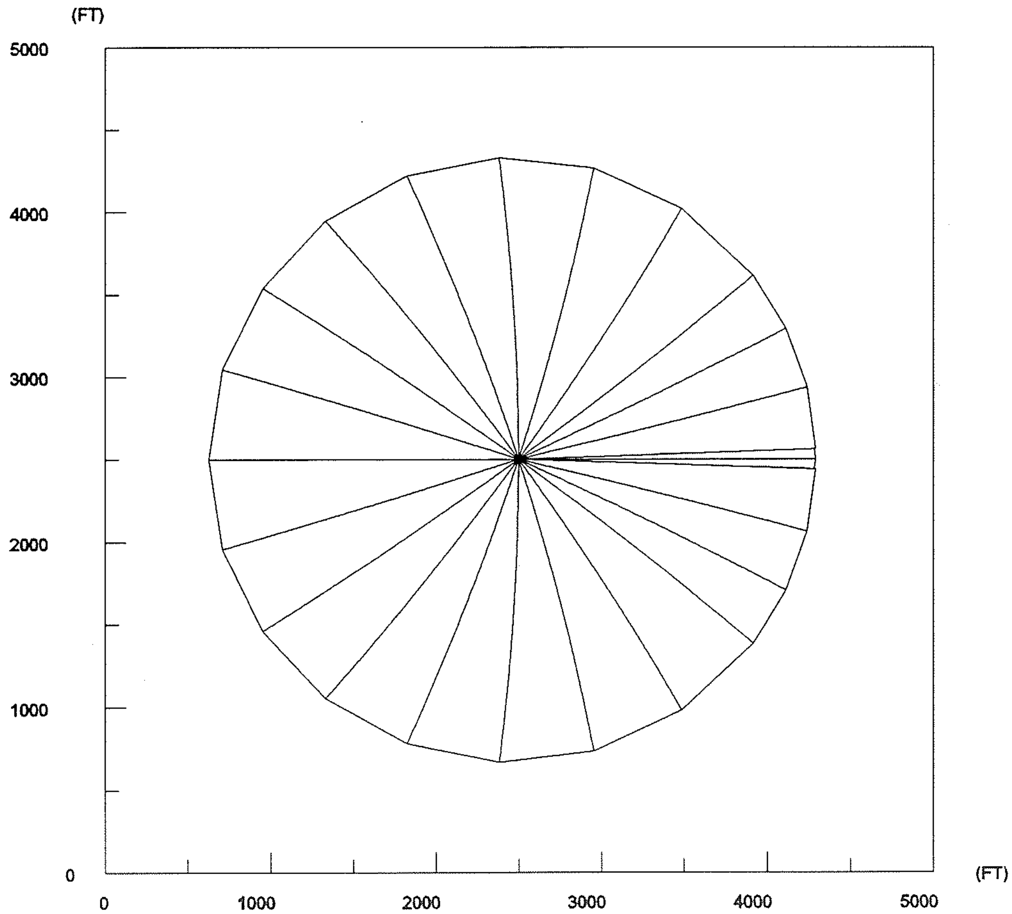
Figure F-1 WHPA Code Plot - East Snake River Plain Basalts



EAST SNAKE RIVER PLAIN BASALTS

Q = 144,000 GPD (100 GPM) = 19251 ft3/day
T = 400,000 gpd/ft = 53,476 ft2/day
b = 600 ft
i = 0.004
Ne = 0.15
Time of Travel = 3 years

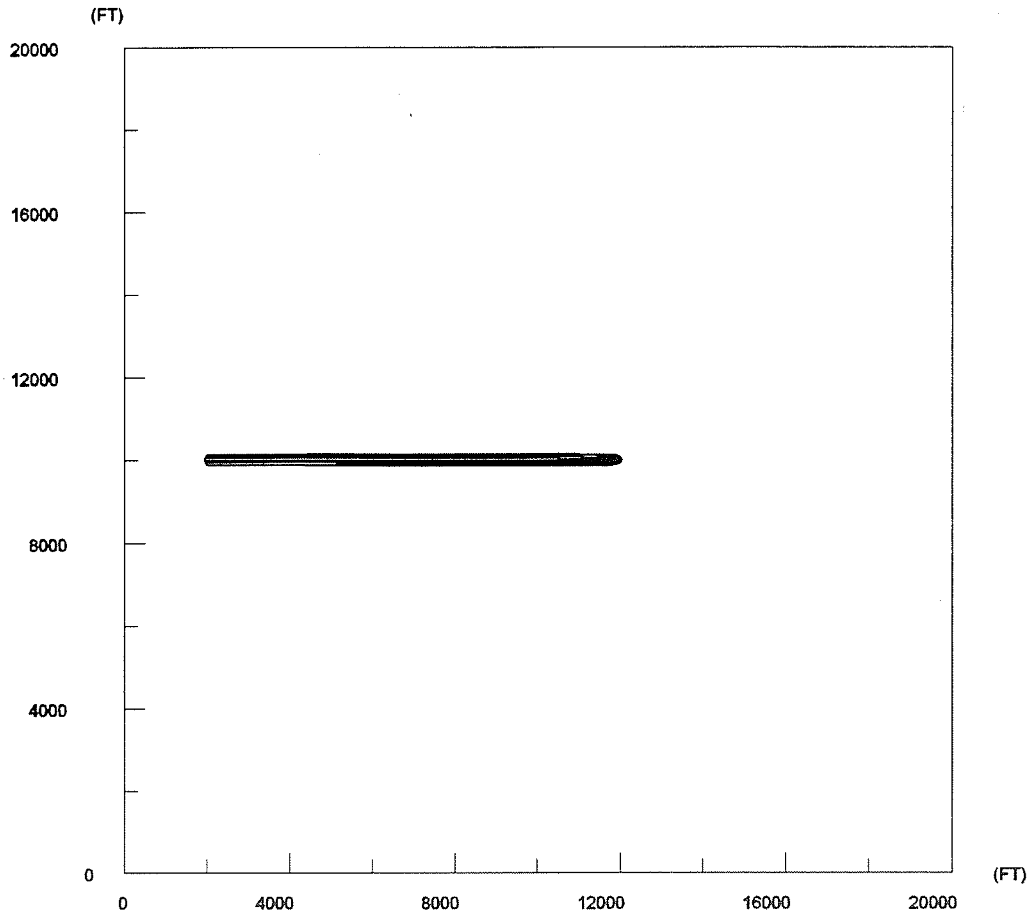
Figure F-2 WHPA Code Plot - Columbia River Basalts



COLUMBIA RIVER BASALTS

Q = 1,440,000 GPD (1000 GPM) = 192,513 ft^3/day
T = 40,000 gpd/ft = 5,348 ft^2/day
b = 400 ft
i = 0.0002
Ne = 0.1
Time of Travel = 6 years

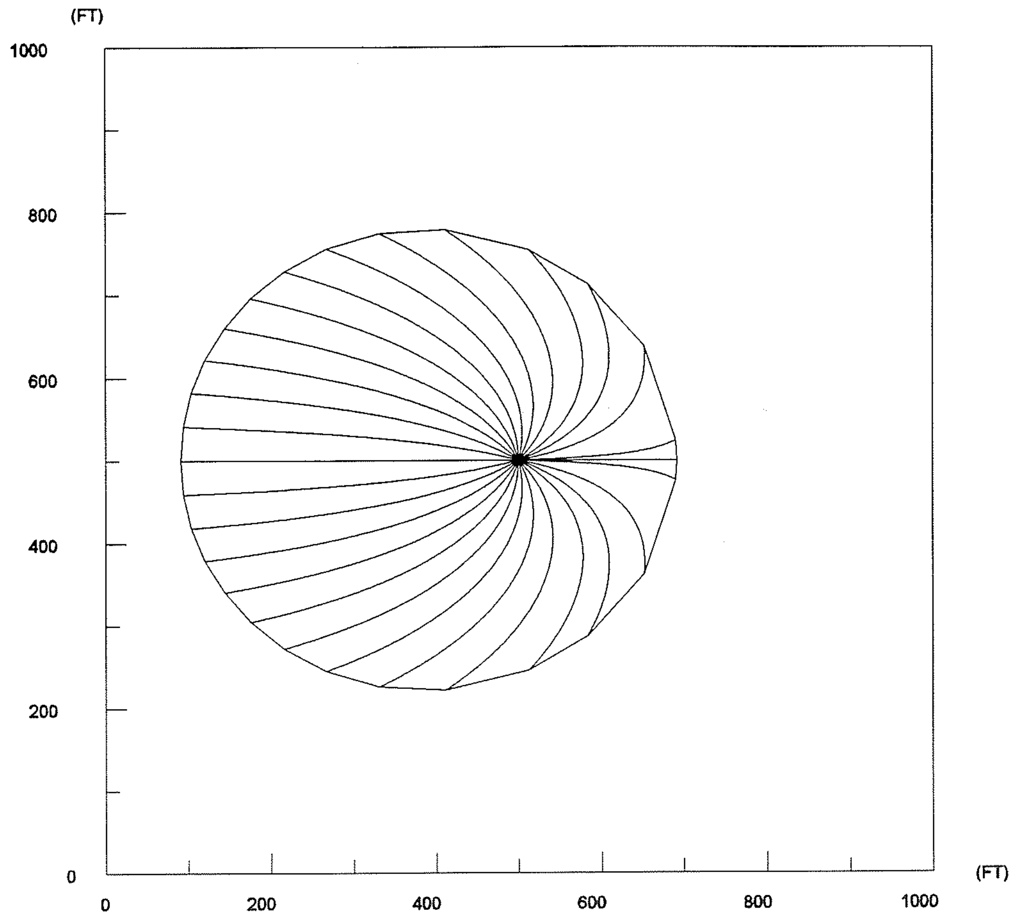
Figure F-3 WHPA Code Plot - Unconsolidated Alluvium



UNCONSOLIDATED ALLUVIUM

Q = 720,000 GPD (500 GPM) = 96,257 FT3/DAY
T = 200,000 gpd/ft = 26,738 ft2/day
b = 100 ft
i = 0.01
Ne = 0.3
Time of Travel = 3 years

Figure F-4 WHPA Code Plot - Mixed Volcanic and Sedimentary Rocks - Primarily Sedimentary Rocks



Mixed Volcanic and Sedimentary Rocks - Primarily Sedimentary Rocks

Q = 144,000 gpd (100 gpm) = 19251 ft3/day
T=30000 gpd/ft = 4010.7 ft2/day
b= 800 ft
i = 0.003
ne = 0.2
Time of Travel = 6 years = 2191 days

WELLHEAD PROTECTION REFERENCES

Barker, R.A., 1979, Computer Simulation and Geohydrology of a Basalt Aquifer System in the Pullman-Moscow Basin, Washington and Idaho: U.S. Geological Survey Water-Supply Bulletin No. 48.

Barraclough, J.T., Lewis, B.D., and Jensen, R.G., 1981, Hydrologic Conditions at the Idaho National Engineering Laboratory, Idaho, Emphasis: 1974-1978: U.S. Geological Survey Open File Report 81-526, 77 p.

Barrash, W., 1991, personal communication.

Bedinger, M.S., Sargen, K.A., Langer, W.H., Sherman, F.B., Reed, J.E., and Brady, B.T., 1989, Studies of Geology and Hydrology in the Basin and Range Province, Southwestern United States, for Isolation of High-Level Radioactive Waste-Basis of Characterization and Evaluation: U.S. Geological Survey Professional Paper 1370-A.

Bjorklund, L.J. and McGreevy, L.J., 1971, Ground-Water Resources of Cache Valley, Utah and Idaho: State of Utah, Department of Natural Resources, Technical Publication No. 36, 72 p.

Chapman, S.L., and Young, N.C., 1972, Water Resources of Western Oneida and Southern Power Counties, Idaho: Idaho Department of Water Administration, Water Information Bulletin No. 25, 69 p.

Clebsch, Jr., A., Waite, H.A., and Decker, S.O., 1974, The Availability of Water in the Little Lost River Basin, Idaho: Idaho Department of Water Resources, Water Information Bulletin No. 37, 60 p.

Cohen, P.L. and Ralston, D.R., 1980, Reconnaissance Study of the Russell Basalt Aquifer in the Lewiston Basin of Idaho and Washington: Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho, 165 p.

Driscoll, F.G., 1986, Groundwater and Wells: Johnson Division, St. Paul, Minnesota 55112, 1089 p.

Drost, B.W., and Seitz, H.R., 1978, Spokane Valley-Rathdrum Valley Aquifer, Washington and Idaho: U.S. Geological Survey open file report, p. 77-829.

Fetter, C.W., 1988, Applied Hydrologeology: Merrill Publishing Company, 592 p.

Garabedian, S.P., 1989, Hydrology and Digital Simulation of the Regional Aquifer System, E. Snake River Plain, Idaho, USGS Open File Report 87237, 140 p.

Gelhar, and others, 1982, Analysis of Two-Well Tracer Tests with a Pulse Input: Rockwell Hanford Operations, RHO-BW-CR-131P, Richland, WA.

Gilbert, R.O., 1987, Statistical Methods for Environmental Pollution Monitoring: Van Nostrand Reinhold Company Inc., 320 p.

Graham, W.G., and Campbell, L.J., 1981, Groundwater Resources of Idaho: Idaho Department of Water Resources, Boise, Idaho, 100 p.

Hammond, R.E., 1974, Ground-Water Occurrence and Movement in the Athol Area and the Northern Rathdrum Prairie, Northern Idaho: Idaho Department of Water Administration, Water Information Bulletin No. 35., 19 p.

Idaho Department of Water Resources and Idaho Department of Health and Welfare, September 1985, Snake Plain Aquifer Technical Report: Boise, ID, 117 p.

Idaho Department of Water Resources, Energy Division, 1987 - 1990, Municipal Water Supply Pump Test Data.

Jones, R.W., and Ross, S.H., 1972, Moscow Basin Ground Water Studies: Pamphlet 153, Idaho Bureau of Mines and Geology, Moscow, Idaho.

Lindholm, G.F., and others, 1983, Configuration of the Water Table, March 1980, in the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon, USGS Open File Report 82-1022.

Lindholm, G.R, 1991, personal communication.

Lindholm, G.F., Garabedian, S.P., Newton, G.D., and Whitehead, R.L., 1987, Configuration of the Water Table and Depth to Water, Spring 1980, Water-Level Fluctuations, and Water Movement in the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon: U.S. Geological Survey Hydrologic Investigations Atlas HA-703.

Lindholm, G.F., and Vaccaro, J.J., 1988, Region 2, Columbia Lava Plateau, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, v. o-2.

Lum, W.E., et al, 1990, Geohydrology and Numerical Model Analysis of Ground Water Flow in the Pullman-Moscow Area, Washington and Idaho: U.S. Geological Survey Water Resources Investigations Report 89-4103.

Luttrell, S.P., 1982, Ground-Water Flow Characteristics in the Mud Lake Area, Southeastern Idaho: M.S. Thesis, 69 p.

Mundorff and other, 1964, Ground Water, Snake River Basin, Idaho: U.S. Geological Survey Water-Supply Paper 1654, 224 p.

Painter, B., 1992, personal communication.

Prickett, T.A. and Voorhees, M.L, 1981, Selected Hand-Held Calculator Codes for the Evaluation of Cumulative Strip-Mining Impacts on Groundwater Resources, Thomas A. Prickett and Associates, Inc., 75 p.

Newton, G.D., 1989, Geohydrology of the Regional Aquifer System, Western Snake River Plain, Southwestern Idaho: U.S. Geological Survey Open-File Report 88-317, 82 p.

Ralston, D.R., and Chapman, S.I., 1968, Ground-Water Resource of the Mountain Home Area, Elmore County, Idaho: Idaho Department of Reclamation, Water Information Bulletin No. 4, 63 p.

Robertson, J.B., Schoen, R., and Barraclough, J.T., 1974, The Influence of Liquid Water Disposal of the Geochemistry of Water at the National Reactor Testing Station, Idaho, 1952-1970: U.S. Geological Survey Open-File Report OF-73-0238, 345 p.

Steele, T.D., Paschis, J.A., and Koenig, R.A., 1988, Hydrogeologic Characterization of Basalts-the Northern Rim of the Columbia Plateau, Physiographic Province and of the Creston Study Area, Eastern Washington: In-Situ, Inc., prepared for the U.S. Nuclear Regulatory Commission.

Squires, E., 1992, personal communication.

Walton, W.C., 1962, Selected Analytical Methods for Well and Aquifer Evaluation, Bulletin 49, Illinois State Water Survey, 81 p.

Young, H.W., 1977, Reconnaissance of Ground-Water Resources: U.S. Geological Survey Water-Resources Investigations 77-108, 19 p.

Young, H.W., Jones, M.L., and Parliman, D.J., 1989, Selected Water-Quality Data for the Rathdrum Prairie Aquifer, North Idaho, September, 1988: U.S. Geological Survey Open-File Report 88-703.

GENERALIZED AQUIFER MAP REFERENCES

Castelin, Paul M., 1976, a Reconnaissance of the Water Resources of the Clearwater Plateau, Nez Perce, Lewis and Northern Idaho Counties, Idaho: Idaho Department of Water Resources Water Information Bulletin No. 41, 46 p.

Castelin, Paul M., and Chapman, Sherl, L., 1972, Water Resources of the Big Wood River-Silver Creek Area, Blaine County, Idaho: Idaho Department of Water Administration Water Information Bulletin No. 28, 44 p.

Chapman, Sherl, L., and Young, Norman, C., 1972, Water Resources of Western Oneida and Southern Power Counties, Idaho: Idaho Department of Water Administration Water Information Bulletin No. 25, 69 p.

Dion, N.P., 1969, Hydrologic Reconnaissance of the Bear River Basin in Southeastern Idaho: Idaho Department of Reclamation Water Information Bulletin No. 13, 66 P.

Dion, N.p., 1972, Some Effects of Land-Use Changes on the Shallow Ground-Water System in the Boise-Nampa Area, Idaho: Idaho Department of Water Administration Water Information Bulletin No. 26, 47 p.

Graham, William G., and Campbell, Linford J., 1981, Groundwater Resources of Idaho: Idaho Department of Water Resources, 100 p.

Lindholm, G.F., Garabedian, S.P., Newton, G.D., and Whitehead, R.L., 1987, Configuration of the Water Table and Depth to Water, Spring, 1980, Water-Level Fluctuations, and Water Movement in the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon: U.S. Geological Survey Atlas Ha-703, 1 sheet.

Newton, Garth, D., 1989, Geohydrology of the Regional Aquifer System Western Snake River Plain, Southwestern Idaho: U.S. Geological Survey Open File Report 88-317, 82 p.

Norvitch, R.F., and Larson, A.L., 1970, A Reconnaissance of the Water Resources in the Portneuf River Basin, Idaho: Idaho Department of Reclamation Water Information Bulletin No. 16, 58 p.

Parliman, D.J., Seitz, Harold, R., and Jones, M.L., 1980, Ground-Water Quality in Northern Idaho: U.S. Geological Survey Water-Resources Investigations Open-File Report 80-596, 34 p.

Parliman, D.J., 1982, Ground-Water Quality in East-Central Idaho Valleys: U.S. Geological Survey, Open-File Report 81-1011, 55 p.

Parliman, D.J., 1986, Quality of Ground Water in the Payette River Basin, Idaho: U.S. Geological Survey Water-Resources Investigation Report 86-4013, 85 p.

Ralston, Dale, R., and Chapman, Sherl, L., 1968, Ground-Water Resource of the Mountain Home Area, Elmore County, Idaho: Idaho Department of Reclamation Water Information Bulletin No. 4, 63 p.

Ralston, Dale, R., and Chapman, Sherl, L., 1969, Ground-Water Resource of Northern Owyhee County, Idaho: Idaho Department of Reclamation Water Information Bulletin No. 14, 85 p.

Ralston, Dale, R., and Young, Norman, C., 1971, Water Resources of the Twin Falls Tract Twin Falls County, Idaho: Idaho Department of Water Administration Water Information Bulletin No. 22, 57 p.

Yee, Johnson, J.S., and Sousa, W.R., 1984, Quality of Ground Water in Idaho: U.S. Geological Survey Open-File Report 83-50, 77 p.

Young, H.W., and Harenberg, W.A., 1973, A Reconnaissance of the Water Resources in the Pahsimeroi River Basin, Idaho: Idaho Department of Water Administration Water Information Bulletin No. 31, 57 p.

Young, H.W., Harenberg, W.A., and Seitz, H.R., 1977, Water Resources of the Weiser River Basin, West-Central Idaho: Idaho Department of Water Resources Water Information Bulletin No. 44, 104 p.

Young, H.W., Jones, M.L., and Parliman, D.J., 1989, Selected Water-Quality Data for the Rathdrum Prairie Aquifer, North Idaho, September, 1988: U.S. Geological Survey Open-File Report 88-703, 1 sheet.

Costs associated with this publication are available from the Idaho Division of Environmental Quality.
DEQ - 200, 80246 Cost per unit, $8.96

Made with recycled materials